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An Alternative Method for Tilecal Signal Detection and Amplitude Estimation

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The Barrel Hadronic calorimeter of ATLAS (Tilecal) is a detector used in the reconstruction of hadrons, jets, muons and missing transverse energy from the proton-proton collisions at the Large Hadron Collider (LHC). It comprises 10,000 channels in four readout partitions and each calorimeter cell is made of two readout channels for redundancy. The energy deposited by the particles produced in the collisions is read out by the several readout channels and its value is estimated by an optimal filtering algorithm, which reconstructs the amplitude and the time of the digitized signal pulse sampled every 25 ns.
This work deals with signal detection and amplitude estimation for the Tilecal under low signal-to-noise ratio (SNR) conditions. It explores the applicability (at the cell level) of a Matched Filter (MF), which is known to be the optimal signal detector in terms of the SNR. Moreover, it investigates the impact of signal detection when summing both signals from the same cell before estimating the amplitude, instead of performing it afterwards as it is currently done. The signal of interest is electronically conditioned to have a well-defined shape (the Tilecal reference pulse shape) and the electronic noise distribution is a Gaussian-like, for which decorrelation can be handled by estimating the whitening transformation of the process. As a result, the MF method implements a finite impulse response (FIR) filter whose coefficients are the Tilecal reference pulse shape.
The MF method is compared to the Optimal Filter (OF) algorithm currently implemented in the Tilecal DSP, which performs the signal reconstruction online. To this end, two classes of data have been used: the noise dataset, which comprises noise signals taken from a pedestal run during nominal Tilecal operation, and the signal dataset, which is constructed from Tilecal reference pulse shape in convolution with added noise. In order to simulate realistic conditions, amplitude and time shifting distributions were taken into account to generate the signal dataset. The results showed that for conditions where the signal pedestal could be considered stationary, the MF filter technique achieves a better SNR performance compared to the OF technique for the tested simulated signals. Current studies include analyzing the behavior of the MF method in conditions where the signal pulse is distorted by the pile-up from additional interactions to the primary collision.

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